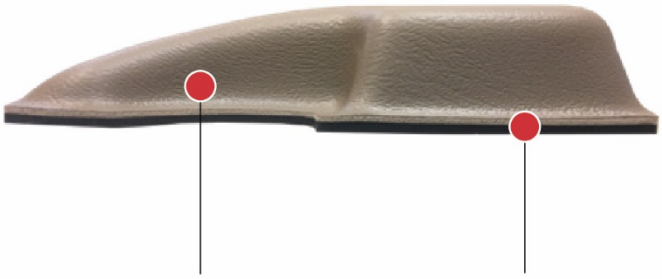
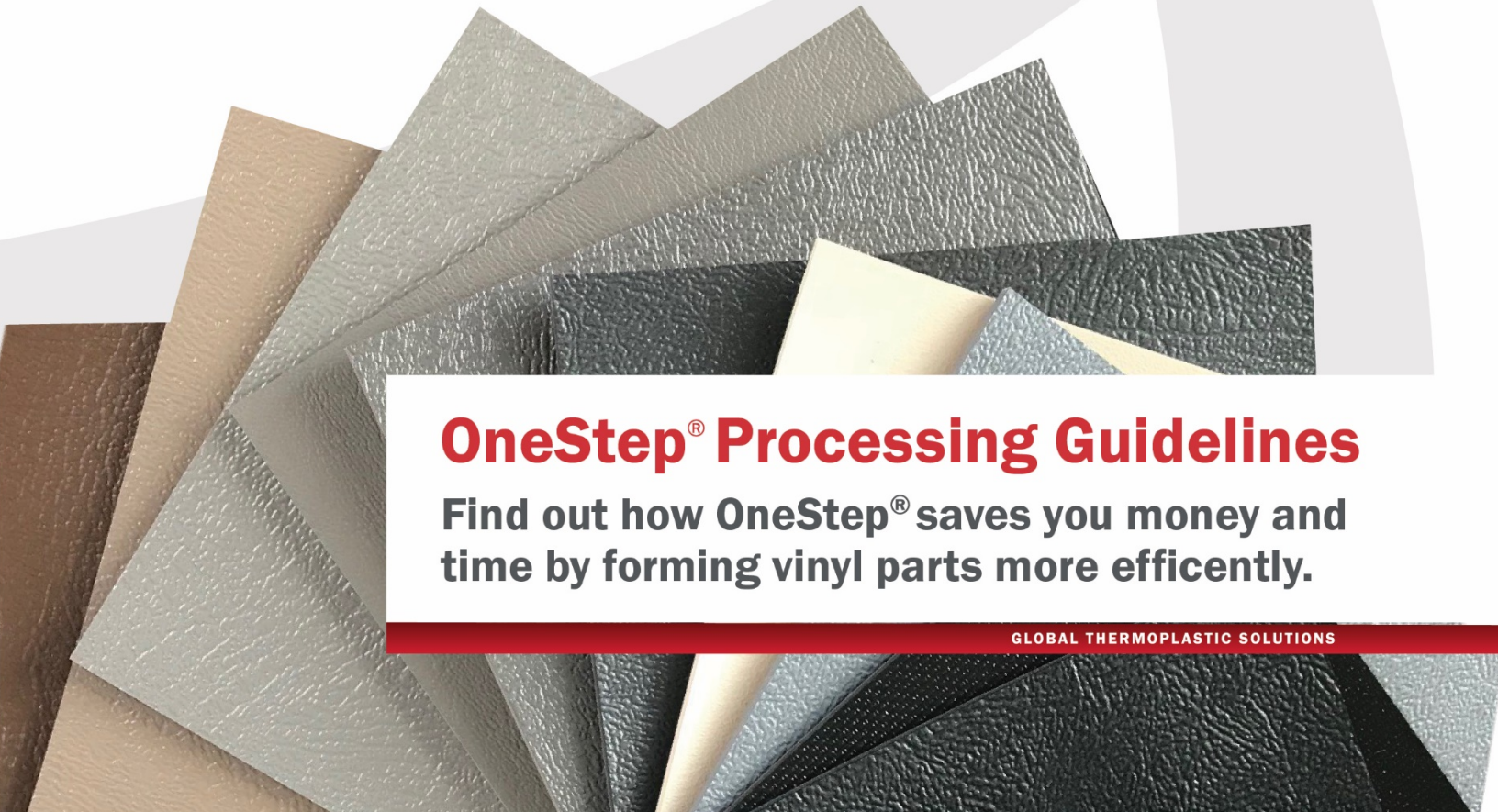
SIMONA PMC

OneStep® Vinyl/ABS



Vinyl Foam Composite with a Leather Texture

ABS



OneStep® Processing Guidelines

Find out how OneStep® saves you money and time by forming vinyl parts more efficently.

GLOBAL THERMOPLASTIC SOLUTIONS

OneStep® Vinyl/ABS

Ask your representative for your OneStep® sample today.

This in-line laminated multi-layer vinyl/ABS sheet system will decrease your production time and labor costs by eliminating the additional step of hand-wrapping vinyl over a thermoformed part. Achieve a durable, leather-like look and feel with no need for adhesives, glues or paints. Available in more than 16 color and texture combinations.

Visit www.simona-pmc.com

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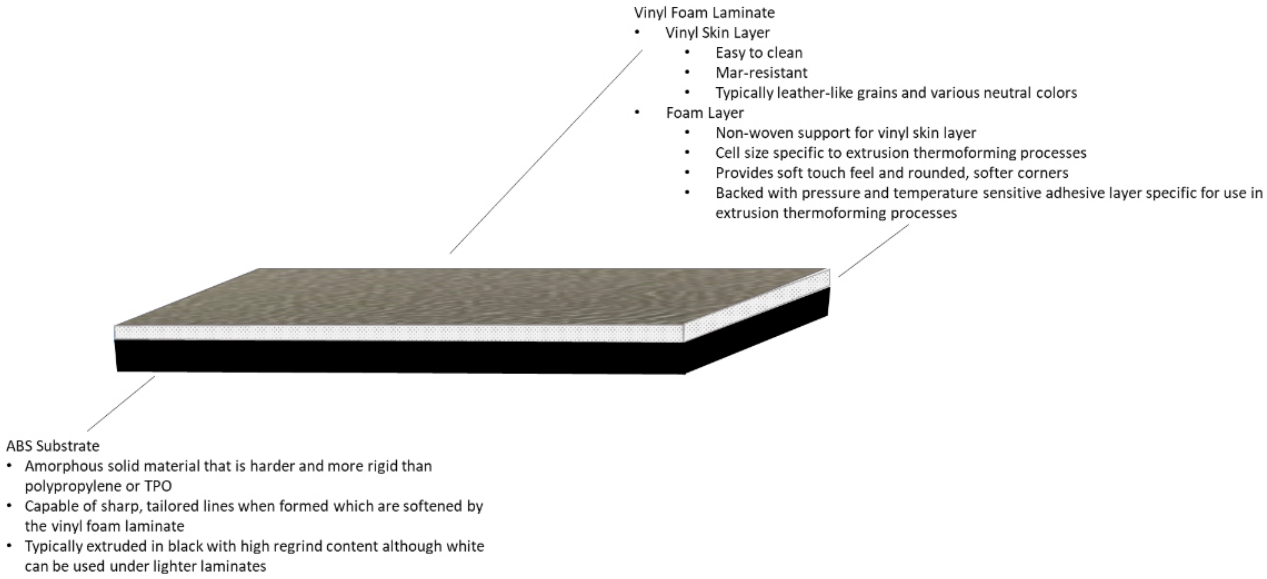
What is OneStep™?

OneStep™ is a vinyl/ABS sheet system from SIMONA PMC, which consists of a soft touch, vinyl foam composite laminated over a rigid ABS substrate. The product provides the opportunity to thermoform a multi-layers part that exhibits the surface durability and outdoor weather resistance of a vinyl laminate with a rigid substrate, while avoiding the labor-intensive process of hand-wrapping parts in two steps. Hence the name – OneStep™



Advantages Over Hand-Wrapping	Disadvantages Compared to Hand-Wrapping
Single step process	Longer cycle time in former than straight ABS
Considerably less labor intensive	Inability to wrap edges may require design changes
Lower scrap rate once process has been established	Scrap is less, but more costly per sheet
Less mess – no sanding/cleaning/adhesive use	Vinyl layer can dent if stacked, particularly if hot
Avoids use of adhesives and PPE required for it	

Common uses for OneStep™ include both interior and exterior components typical, but not limited to, in the heavy truck, bus, van, recreational vehicle (RV), and marine industries. OneStep™'s low gloss and soft touch characteristics make it deal for interior panels, dashboards and headliners while its excellent weatherability and durability make it an ideal choice for exterior components as well.


Marine Dash with Vinyl Wrap


RV Interior Panel


Heavy Truck Headliner

Technical Data

Physical Characteristics

- **Sheet Weight**

  The vinyl foam laminate comes from the supplier at a typical thickness of 0.085 inches (some is a thinner 0.070 inches). A typical rule of thumb for the vinyl laminate is to add 0.31 lbs/ft^2 to the ABS weight to get total sheet weight. Some typical sheet weights are calculated in the table below:

ABS Thickness	Vinyl Laminate Thickness	Approximate Weight
0.080"	0.085"	0.74 lbs./ft^2
0.125"		0.99 lbs./ft^2
0.150"		1.12 lbs./ft^2
0.200"		1.39 lbs./ft^2
0.250"		1.66 lbs./ft^2

- **Sheet Thickness**

  OneStep™ sheets are produced in a variety of thicknesses to suit the thermoformed part requirements. Usually, the customer specifies the ABS thickness alone without including the thickness of the vinyl foam laminate layer, as most of the part's stability comes from the ABS substrate. SIMONA PMC currently extrudes OneStep™ product in thicknesses from 0.080 – 0.250 inches ABS thickness (0.165 – 0.335 inches with the laminate) although thicknesses outside of these ranges could be trialed as well.

- **Gardner Impact Resistance**

  OneStep™ sheet has improved impact resistance results over standard ABS for A surface Gardner (drop dart) impact due to the impact absorbing capabilities of the vinyl foam laminate. The below results are for two of the most common OneStep™ thicknesses, specified by ABS thickness only, at both 23°C and -30°C. Three total replicates of each thickness were tested and the average is below:

Thickness	Gardner Impact @ -30°C	Gardner Impact @ 23°C
0.160" OneStep™	124 in-lbs.	305 in-lbs.
0.200" OneStep™	143 in-lbs.	320 in-lbs.
0.100" ABS Only	68 in-lbs.	122 in-lbs.
0.125" ABS Only	77 in-lbs.	141 in-lbs.

  ABS as a material has poor cold-temperature impact capabilities, which is noted in this data at -30°C. Increasing thickness of the substrate can help drastically improve the impact resistance. In addition, ABS is commonly known to be notch sensitive. Although the vinyl foam laminate likely also provides some resistance to this mode of failure as well, care should be taken to avoid notches or weak points in formed parts or attachment areas.

- **Tensile Strength**

  OneStep™ Vinyl/ABS has a tensile strength of 24.9 MPa (3,611.44 lbs/in^2) at 0.160" thickness and 30.1 MPa (4,365.64 lbs/in^2) at 0.200" thickness using ISO 527 test method. Most ABS materials list tensile strength of around 30-35 MPa (4,350 – 5,075 lbs/in^2). The utility ABS content (up-to-and-including 100% regrinds ABS) of the OneStep™ substrate layer may be diminishing the typical ABS value slightly. Most of the tensile strength of the OneStep™ system comes from the rigidity of the ABS substrate layer.

- **Elongation at Break**
  The vinyl laminate layer lists elongation at break on its own of 190%. However, the ABS substrate layer is likely to fail first with an elongation at break of 100%.

- **Mold Shrink**
  Since the ABS substrate makes up the majority of the sheet system, typical ABS mold shrink of 0.5 - 0.8% is likely to occur. It is important to note, however, that shrink for the vinyl laminate alone is 1.0 – 3.0%, which could contribute to tearing of the vinyl layer away from the substrate if cooling is too rapid.

Surface Appearance and Durability

- **Gloss**
  OneStep™ is considered a low gloss product with a typical range of 2.0 - 6.0% on a Gardner 60° gloss meter and many texture/color combinations under 3.0% gloss.

- **Surface Abrasion and Mar Resistance**
  The vinyl laminate layer of the OneStep™ product offers excellent abrasion and mar resistance. The laminate data sheet lists no color change after 500 cycles of Taber Abrasion using a CS-10 wheel under a 1000-gram load. Some loss of gloss is expected. For croc mar, the vinyl foam laminate shows no staining after 10 strokes using the AATCC methodology. SIMONA PMC also performed croc mar testing using the ISO methodology (10 strokes) and obtained the following results:

	Bison Texture Black 0.200”	Wallaby Texture Slate Gray 0.145”
Delta L* (lightening/darkening)	-1.86 (darkened)	-0.06 (no appreciable change)
Delta E* (overall color shift)	1.87 (mostly darkened)	0.16 (no appreciable change)
% Gloss Retention	71.43% Retained	64.14% Retained

Weathering and Operating Temperatures

Although ABS is not considered weatherable on its own, the vinyl laminate provides a weatherable surface. No appreciable color change was seen (DE* 0.28) after 340 hours under SAE J2527 Outdoor Automotive testing at 340 nm. No yellowing or color change or loss of embossed grain is expected after 72 hours at 93°C (200°F). Similarly, no discoloration or loss of grain is observed after 16 hours at 38°C (100°F) and 100% relative humidity.

Finished thermoformed parts get most of their rigidity from the ABS substrate layer. While the vinyl foam laminate is listed as ductile down to -30°F, ABS becomes prone to cracking at this temperature. Care should be taken to avoid impact situations in extreme cold weather conditions due to the ABS substrate. On the upper end, OneStep™ can withstand temperatures of up to 175°F before seeing deflection of the ABS substrate and/or off-gassing of the vinyl foam laminate layer.

Flammability and Safety Considerations

- **Flammability**
  Most standard ABS grades can meet the “HB” (Horizontal Burn) requirements under UL 94 standards, at multiple thicknesses. The vinyl foam laminate layer does pass FMVSS302 with a maximum burn rate of 4 inches/minute. SIMONA PMC also tested two thicknesses of OneStep™ in flat sheet form and both pass FMVSS302.

Specimen	Burn Time (s)	Burn Length (mm)	Burn Rate (mm/min)
0.125" Thickness ABS + 0.070" Vinyl PVC Laminate			
1	0	0	Self-Extinguished
2	0	0	Self-Extinguished
3	0	0	Self-Extinguished
0.200" Thickness ABS + 0.070" Vinyl PVC Laminate			
1	0	0	Self-Extinguished
2	0	0	Self-Extinguished
3	0	0	Self-Extinguished

Data from Element Laboratories report EWA113652P dated 3/17/2020

- PPE Considerations

  When handling raw sheet or parts under 175°F, safety glasses and cut proof gloves are recommended. Once thermoformed parts are assembled in their final state, no PPE is required under 175°F. Over 175°F, which is likely encountered during the thermoforming process, local ventilation is recommended.

- Firefighting Measures

  In the event of a fire, extinguish with water, foam, dry chemical or carbon dioxide. Carbon dioxide is recommended for any fires inside of thermoforming equipment to avoid additional damage to heating elements being cause by the extinguishing agent. Care should be taken when fighting fires as the vinyl foam laminate can produce toxic combustion products, including hydrochloric acid (HCl).

Design Considerations

Color and Texture

When designing for OneStep™, there are several things to consider during the early stages of part and tooling design. The first is the choice of color and texture. The vinyl laminate type is specific to the extrusion and thermoforming process, so not all colors and textures represented in the vendor's portfolio are available for use in OneStep™. For a list of currently available color and texture combinations, refer to the SIMONA PMC website: SIMONA-pmc.com. Custom color and texture combinations can be produced; however, typical lead-time on a new vinyl match is approximately 12 weeks, with specific minimum order quantities, so this process is best started as early as possible during the design phase.

Sheet Widths and Web Utilization

A second major consideration is determining sheet width. Since the OneStep™ vinyl laminate is produced in standard widths, maximizing efficient utilization of these laminate widths can greatly affect total sheet economics.

The vinyl laminate comes in standard widths of 48, 50, 54, and 61 inches. In the extrusion process, the vinyl must be fully supported by ABS plastic, so excess trim in the width direction can be costly. It is a best practice to design tooling or sheet sizes to be within 2 - 5 inches of the standard vinyl laminate widths, over or under.

SIMONA PMC's extrusion lines have the capability to run multiple sheets in parallel (2 or 3 sheets across in some cases depending in width), which could help in utilization. Another option for using the full width of the vinyl laminate is to "flip" the extrusion direction of the sheet, running what would normally be the width as the length. For help determining ideal dimensions, contact to your SIMONA PMC sales or technical service representative.

Thermoforming Methods and Tooling Design

OneStep™ can be thermoformed with many of the common methods used for ABS including drape forming, vacuum forming and pressure forming. Vacuum forming over a positive tool is the most common, however, pressure forming into a negative tool can take advantage of the vinyl laminate's compressibility to provide surface details such as logos or other designs. The caveat here is that the negative tool surface will need to be pristine to avoid any unwanted denting of the vinyl surface in other locations.

OneStep™ Pressure Formed Details

Draw Ratio

The recommended maximum draw ratio for OneStep™ is 2:1 due to the restriction of the vinyl laminate layer. Over-drawing the material can result in taring of the laminate's foam layer and/or surface. Elongation at break for the laminate is 190% in both machine and transverse directions according to the technical datasheet. Extrusion stretches the material some, mainly in the machine direction, around 30%. This leaves a total elongation in the machine direction of 160% prior to break. Greater draw depths may be obtained using the snap-back or reverse snap-back methods where the material is pre-drawn into a pressure box before being released and formed on the mold, although this is not common practice.

Corners and Radii

ABS forms well to a high definition but the vinyl foam layer of OneStep™, while providing a soft touch feel, also cannot create the same sharp curves and corners. Radii of at least 0.5 inch, or a 45 degree mitered corner, are recommended when designing parts for use with OneStep™. A tighter corner may result in tearing of the vinyl laminate's foam layer, while a tight radius could result in the laminate layer wrinkling into the bend as in the photo below. Some smaller, shallower draw parts (<12 inches maximum draw depth) could get away with 0.25 inch radii while very large, deep draw parts may require up to a 1 inch radius.

Slight wrinkling into tight radius

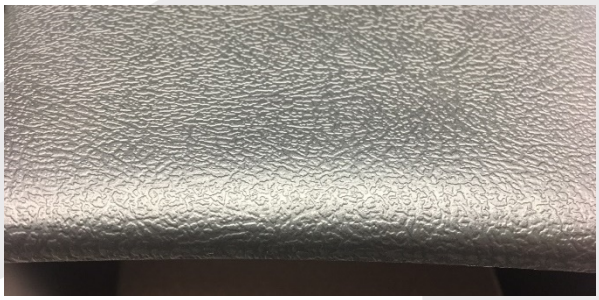
Shrink Rate

Shrink rate is always an important factor when designing tooling. OneStep™ has shrink rates similar to straight ABS when formed, around 0.5 - 0.8%. The vinyl laminate layer on its own would have a shrink rate of 1.0 – 3.0% if not adhered to the ABS so if forming too cold (< 290°F), some tearing of the laminate from the ABS substrate could occur, particularly around the edges of the sheet.

Edge Design

While OneStep™ offers numerous advantages in processing time and ease of use, the one drawback to the product line compared to hand-wrapping is the inability to wrap the edges of the parts with the vinyl. Parts made with OneStep™, will show the ABS substrate layer one the edges unless the parts/tooling are designed to hide the exposure. Typically, this is accomplished by incorporating a downturned flange along the sides of the parts such that the raw edge is not exposed in the end use. Be careful not to design the flange in such a manner that the part is die-locked to the tool.

Example of exposed OneStep™ Edge



Example of a Design with Turned Down Edge

Molds and Mold Materials

Mold choice for OneStep™ will be similar to that of ABS except that cooling will likely be longer due to the insulating properties of the vinyl laminate.

Wood or fiberglass tooling could be a good option for development and trial parts due to the cost effectiveness of the materials, however cooling the tool between shots will be problematic with OneStep™. Eventually, especially with a wooden tool, degradation of the tool surface will occur. It is recommended that a hardwood be used with a

protective release coating to delay degradation. Keep in mind if considering fiberglass tooling that dimensions may be slightly different on parts made with a cold tool vs. one that is warmer from repeated use.

Epoxy or ceramic molds can also be used for OneStep™ and are going to be considerably more durable than the wood prototype molds. However, both of these mold material options, particularly ceramic, are thermal insulators and can be difficult from a cooling perspective compared to metal. This cooling issue will be particularly limiting if you are using a rotary type of thermoformer where the cooling time for the tool is limited by the heating time for the next.

Aluminum, particularly temperature-controlled, is the most cycle time efficient (but most expensive initial investment option) for forming OneStep™ materials. This is the durable mold material option as well and is all but required if you are considering a rotary machine and intend to produce several parts in series.

Processing OneStep™

Moisture and Sheet Drying

The ABS substrate of the OneStep™ material is hygroscopic, which means that the core material will take on moisture from the ambient air and this is absorbed into the polymer matrix. Moisture can be a problem in ABS sheet, and therefore OneStep™, because upon rapid heating, such as in the thermoforming process, the moisture is boiled off, leading to a bubbling or pitting of the surface as the water vapor escapes. The defects are permanent once formed and the part must be scrapped out. In OneStep™, the moisture cannot all escape from the B-surface and some is released through the vinyl foam laminate layer causing various surface defects on the vinyl side as well.

Example of moisture issue in ABS causing an A side defect

SIMONA PMC packages OneStep™ materials in a polybag to prevent excess moisture from getting to the sheet. There are also desiccant packets included in the packaging to scavenge any moisture remaining in the polybag. This means that the OneStep™ product should be well protected from moisture until it arrives to the customer. Once at the customer, it is recommended that once opened, an entire skid is used at once if at all possible. If there is left over material, it is best to seal back up the polybag as well as possible, leaving the desiccant in the packaging so that it can continue to scavenge moisture. Re-sealing is typically sufficient if done with normal packaging tape

as long as all seams are covered completely. SIMONA PMC also uses desiccant that is color changing. As the desiccant absorbs moisture, the color changes from a bright blue through a purplish hue to a bright pink. Once the packet turns a pink color, the desiccant is spent and is no longer effective at removing moisture. If this occurs, it is best to replace the desiccant with fresh or use up the sheet rather than continue to store it where it can take on moisture.

Spent desiccant pack (left) vs. fresh one (right)

In the event that OneStep™ is exposed to ambient conditions for a period of time, and moisture absorption is a concern, the product can be dried similarly to normal ABS sheet. If you have a sheet dryer, or access to one, OneStep™ should be dried at around 190°F for 8 - 24 hours (time will depend on sheet thickness).

Top Versus Bottom Platen

OneStep™ can be thermoformed successfully on either the top or the bottom platen. Typically, the platen is chosen based on clearance in the former and depth of the part being formed. There are a couple of additional considerations when forming OneStep™. The first is distance of the vinyl laminate layer from the heating elements. The vinyl layer of OneStep™ absorbs heat very quickly and easily burns. Therefore, it is beneficial to form the sheet such that the ABS substrate is closer to the heating elements than the vinyl foam laminate is.

A second consideration is the weight of the laminate layer when the sheet is heated. The vinyl laminate can weigh down the ABS if the laminate faces up and cause some additional sag, which could result in edge tearing. If the laminate does not go all the way to the edges of the sheet, this can also cause some thinning around the clamp frame where the ABS is uncovered by laminate. This effect will be less apparent on thicker ABS substrates than thinner. On a 0.250 inch ABS substrate the vinyl layer will account for approximately 19% of the total sheet weight, however on a 0.125 inch ABS substrate the vinyl layer accounts for nearly 32% of the total weight, greatly increasing the likelihood that the vinyl layer will weigh down the ABS in the former.

Types of Heating Elements

OneStep™ can be thermoformed using a variety of machines and oven element types. No matter what type of heating element is used, most of the heating for OneStep™ should be done from the ABS side of the sheet to avoid

burning of the laminate. Particularly if you are using an oven with heaters on only one side, you should make sure to hang the mold so that the ABS side is facing those heaters. If your oven has elements on both top and bottom, they should be separately controlled so the laminate side can be heated less than the ABS side. It is also critical that heating of OneStep™ be as even as possible. Hot spots could cause scorching or thinning in some areas while cooler spots may not stretch as well and could tear the laminate layers.

- Nichrome Wire

  Nichrome wire is probably going to be one of the more difficult heating elements to use with OneStep™. This is something similar to the wire in a toaster. Electrical current travels through the wire to heat it up which in turn heats the sheet. The main issue with these heaters is that they do not heat uniformly. It is very difficult to avoid getting some hot spots and some cold spots. With OneStep™, this can cause burning in some areas of the sensitive laminate and tearing in others where it is too cold. These elements also tend to burn out relatively quickly because they degrade when exposed to the air so maintenance can be high. However, the benefit is that nichrome wire is one of the lowest costs out of the gate but this is going to be paid for later through inefficiencies.

- Calrod

  Calrods are more expensive than nichrome wire but are still reasonably inexpensive compared to ceramic or quartz. The calrod is similar to the heating elements in an electric oven like the one you may have in your kitchen. Calrods can be zoned to give more control over the different sections of the oven, which can help to avoid hot or cold spots but the cost increases the more zones you add. Electrical current to calrods are either on or off and when on fully (100% of the time), can reach temperatures of 1300°F on the surface. This will burn most plastics and definitely the laminate layer of OneStep™, so temperature of the oven is controlled by turning the elements on and off on some frequency, typically around 50% on, 50% off, by time. This mode of operation does lead to some inconsistency of heating but the calrods do hold heat better than nichrome wire so more even heating than the wire option. The main drawbacks of calrod heating is that they take a longer time to heat up and cool down so it is difficult to change temperatures, the heating is still somewhat non-uniform and they do deteriorate quicker than ceramic or quartz, increasing maintenance costs.

- Gas Catalytic

  Gas catalytic heaters are still in use today and are a relatively inexpensive option for forming plain ABS. However, these ovens do present some challenges for forming OneStep™. The vinyl foam laminate of OneStep™ is sensitive to over or under heating, so control of temperature is important. With gas catalytic heaters, it is easy to create hot or cold spots depending on how the gas flow is controlled into the heaters. This is made worse if there is a large number of panels in the former. The uneven temperatures can burn the laminate creating bubbling or scorching or tear the laminate if it doesn't get hot enough. Also, while gas catalytic can be inexpensive to startup, they are more high maintenance than other heating options due to their susceptibility to dead spots.

- Ceramic or Quartz

  Ceramic or quartz heaters are probably the most efficient means of forming OneStep™ but are also more expensive to start with. When zoned properly, these heater types create the most even heating of the product and are easier to control, allowing the former to adjust the heats so avoid damaging the laminate

layer and to do most of the heating of the sheet from the ABS side. Ceramic heaters are a little less expensive than quartz but have a slower response time. This means that changing temperatures is going to take longer and the oven will take longer to both heat up and cool down. Quartz heaters will react much quicker but they are more expensive and more fragile which could lead to higher replacement costs if they are not well maintained.

Heating Element Type	Suitability for OneStep™
Nichrome Wire	Not Recommended
Calrod	Capable
Gas Catalytic	Not Recommended
Ceramic	Recommended
Quartz	Recommended

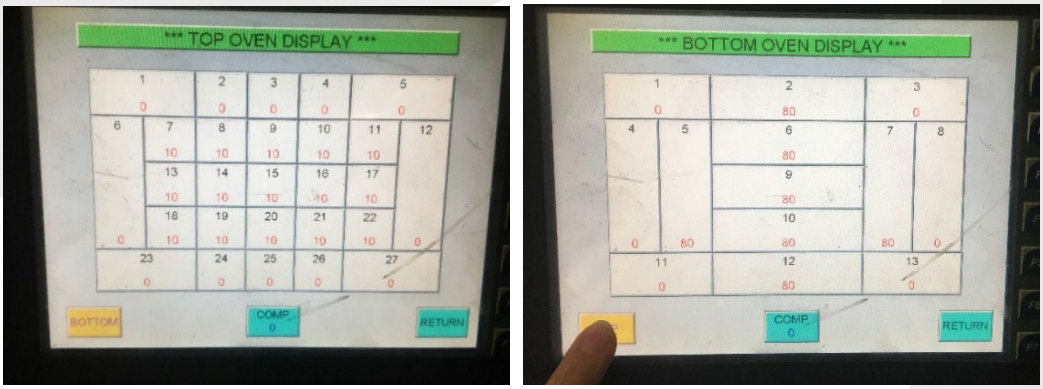
Forming Temperatures

As mentioned in the previous section, the most important things when forming OneStep™ are ensuring that most of the heating is done on the ABS substrate side and that temperatures are as uniform as possible in the oven.

The vinyl laminate side is sensitive to high temperatures and can scorch or blister easily. The surface temperature of the laminate side of OneStep™ should only get to 290 - 310°F during the heating cycle, whereas the ABS side can withstand 400 - 410°F. Many times, this means little to no heating from the A (vinyl) side.

This allows most of the heating to occur from the B (ABS) side of the sheet and soak heat through the core to the vinyl laminate. One easy way to tell if the laminate is getting over heated is to look for smoking during forming. Nothing should be smoking during the heating of the sheet, as smoking is a good indication of overheating the laminate surface. Rapid heating is recommended by the laminate supplier to avoid extended time in the oven, which can burn the vinyl. However, longer oven times are still likely to be encountered compared to plain ABS forming because the properties of laminate insulates the ABS somewhat from heating.

The recommended temperatures of 290 - 310°F on the A side and 400 - 410°F on the ABS side are actual surface temperature recommendations. Since thermoforming machines vary widely with different potential heating elements and distances of the surfaces from the heaters, it is difficult if not impossible to recommend thermoformer settings in terms of percentage of time on/off of the elements or temperatures of the elements themselves. However, SIMONA PMC's oven setup is provided below for OneStep™ product. Most commonly, surface temperatures can be obtained using a manual infrared (IR) heat gun. This works relatively well, but can be affected by anything that gets in the way of the laser, including dust in the air, or by reflective surfaces, such as the ABS substrate surface in some cases.



SIMONA PMC Oven Settings for OneStep™ Material

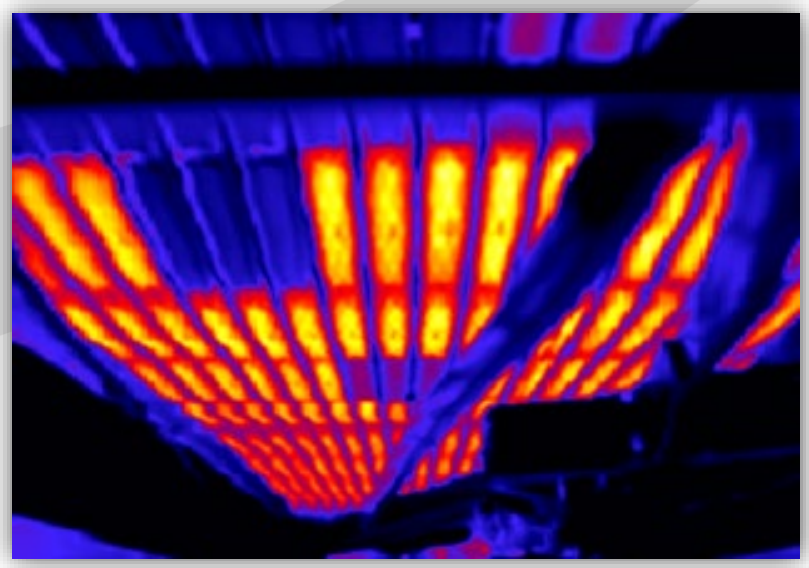
Heat Tapes

A more accurate method to determine surface temperature of a part is to use temperature tapes. These single-use "heat tapes" are applied directly to the sheet surfaces and show squares at various temperatures. The squares turn black permanently once that temperature is encountered during thermoforming. This allows you to see exactly how hot the actual surfaces got. Multiple tapes may be needed on each side to cover the full range of possible temperatures. The downside to the temperature tapes is that they will ruin the part. The tapes cannot be removed and often create a ridge where the tape was applied. Therefore, while they are a more accurate way to determine surface temperature, heat tapes are most useful during troubleshooting or prototyping. If interested, Paper Thermometer sells various temperature tapes online at: paperthermometer.com.

Heat Tape Pre-Forming

Heat Tape Post-Forming

The second temperature consideration when forming OneStep™ is temperature uniformity in the oven. Being too hot in one area, typically deeper draw areas or around clamp frames, can cause localized blistering or scorching while being too cold on one area compared to another can cause the vinyl laminate to tear away from the ABS core when pulled over the mold. If hot or cold spots are suspected in the process, the first place to check would be the oven elements to ensure that they are functioning similarly across the oven.



Infrared Camera of Heating Elements in Former Oven

Ambient Air Flow

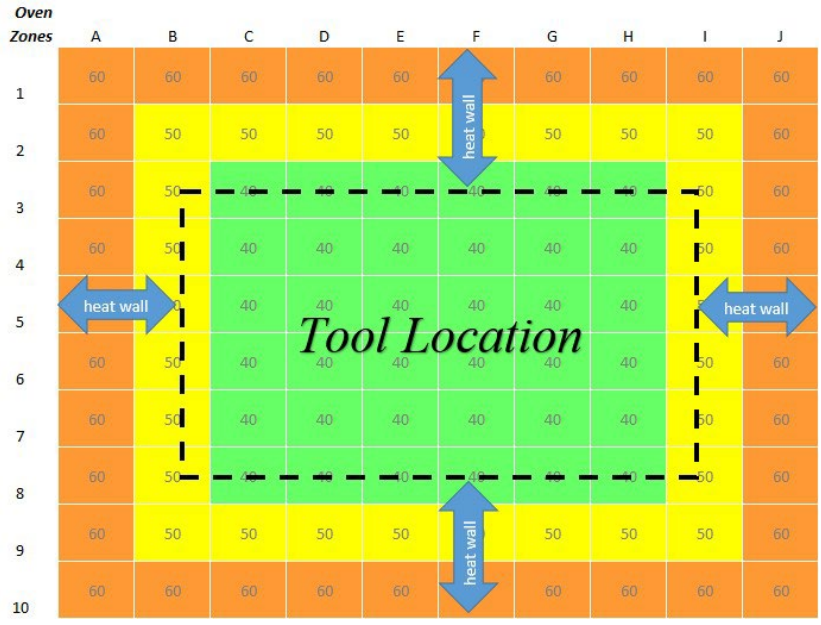
Another common cause of cold spots in an oven is air drafts, particularly in ovens that do not have enclosure around the heating area. Check the surroundings for open overhead doors or fans that could be causing a draft while the part is in the former. Again, using an infrared camera can really be helpful here. Watch the oven during the entire heating cycle and see if any drafts are present.

Anemometers or vane airflow meters can also help you to measure airflow around your ovens. These are handheld, relatively inexpensive and easy to use. Check airflow around all sides of the former and see if there is any area with significantly more or less airflow than others. Then look for the cause of the drafts and eliminate them.

Example of an Air Flow Meter from extech.com

- **Advantages of a "Heat Wall"**

  Combat ambient plant floor drafts & protect against heat sinks around the edges of the tool by creating a heat wall a minimum of 6 - 8 inches from all edges of the sheet in the oven. What this means is not allowing the heating elements to be on only to the edge of the sheet and then off directly outside of that. Keep elements on at a similar heat at least a good 6 - 8 inches past all edges of the sheet. That way, if there is air flow or similar temperature gradient, it can be mitigated within the heat wall and does not cause a cool spot on the part. Keep in mind that to do this, the clamp frame & tool must be somewhat centered in the oven, not pushed all the way to one side or the other to the edges of where the heating elements are.



Heat wall example

Hot spots in the former can also be an issue when forming OneStep™. If you suspect there are elements or areas in the oven that are too hot compared to the rest of the former and you don't have the option to control this with zoning of the elements, screening is an option. Placing a *metal* mesh screen over the elements in the hot spot (but not touching the elements) will block a portion of the radiant energy from the sheet and result in a cooler surface temperature in that location. Be sure to use metal screen and not a polymer or fiberglass mesh, which could melt being so close to the heating elements.

- **Part Cooling**

  The vinyl laminate absorbs and releases heat readily from its surface but the foam layer acts to insulate the ABS. This makes OneStep™ slower to cool than a non-laminated ABS sheet. Longer cooling times once the part is formed to the mold will be typical and fans are likely to be needed to get the part to cool evenly. Similar to the importance of uniform heating, OneStep™ forms best when cooling is uniform as well. Areas cooling slower than others, particularly in sharper corners or deeper draw areas can see a "tenting" effect of the vinyl laminate where the outer layer of the laminate pulls away from the inner foam and adhesive layers in some spots. Adding fans in these areas can help to eliminate this issue.

Example: Vinyl "tenting" issue

- **Handling**

  Some care must be taken when handling OneStep™ post-formed parts. The vinyl foam laminate of OneStep™ can be slow to recover from minor impacts or impressions. The laminate easily dents and can often experience a permanent surface deformation with enough force and exposure time. Avoid stacking formed parts on top of one another, especially when warm, as denting on the corners is likely to occur and is not reversible. Use of cooling racks to keep parts separated and elevated are recommended. Even getting small debris such as router waste between sheets or parts can cause permanent indentations to the vinyl.

- **Trimming**

  OneStep™ can be routed and trimmed similarly to ABS using a hand router or CNC machine. It is recommended that a router bit with an "up flute" design be used to avoid excess chaff from the vinyl laminate layer stretching during routing. Router speed and trim rate will need to be determined by the part producer as each application's needs vary. Again, be careful to avoid rough handling or severe impacts to formed parts. Whereas most ABS grades have some impact resistance, they are still more prone to cracking and notch sensitivity, particularly at cold temperatures.

Example of vinyl laminate chaff from routing and an “up flute” bit

- **Bonding and Adhesives**

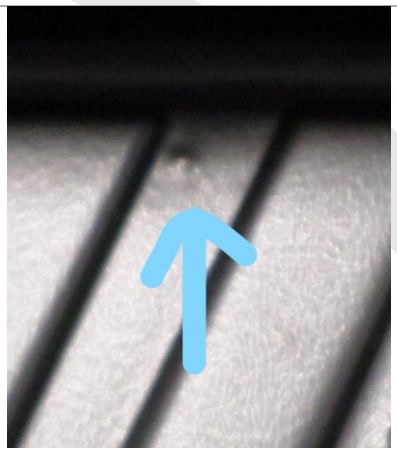
  If bonding OneStep™ to other parts or reinforcements, typical ABS adhesives (epoxies, urethanes, etc.) can be used on the ABS substrate side. OneStep™ can be screwed or riveted together as well but take care due to the notch sensitivity of ABS. Pre-drill any holes a little larger than needed in order to allow for some thermal expansion and use flat washers on both sides of the attachment. Avoid over-tightening screws and use flat head screws if possible to reduce stresses on the ABS. It is also recommended that fasteners be cleaned prior to use to avoid getting any chemical degreasers onto the plastic. This can prematurely degrade the polymer and lead to early cracking at attachment points. Lastly, be mindful of the total thermal expansion needs for larger parts. The use of expansion wells, slots, and nested parts will help safeguard against cracking at attachments due to extensive thermal expansion or contraction under temperature extremes.

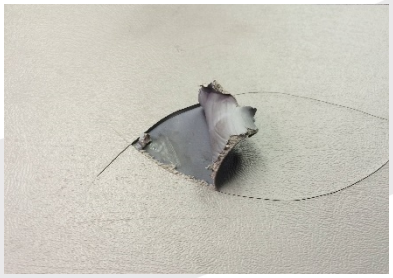
Disposal Methods

Inevitably, there will be some scrap from the thermoforming process, in either routed trim pieces or parts that do not pass quality expectations. Unfortunately, OneStep™’s unique properties is due to the bringing together of several dissimilar material types (ABS, foam, adhesives, and PVC) and cannot be recycled back into the extrusion process as regrind. Please dispose of any scrap in a safe manner and in accordance to local laws and practices in your area. It is not recommend to incinerate or burn OneStep™ trim or scrap parts.

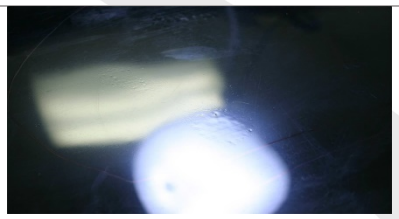
Common Issues and Troubleshooting

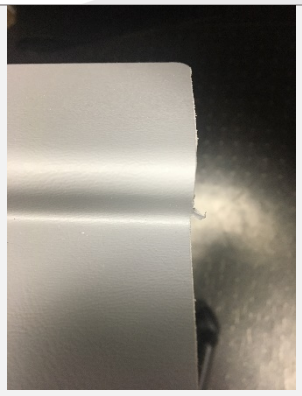
Issue	Photos	Potential Causes	Troubleshooting
Blistering/ bubbling of laminate	 	1. Off-gassing of volatiles in the foam layer of the laminate 2. Scorching or burning from being too hot on A surface 3. Uneven or too rapid of heating 4. Moisture in the ABS layer escaping through the surface	1. Cut open sample to see where bubbling starts. If only at very top of laminate and no damage to foam cells, likely off-gassing. 2. If it got too hot, you may see bubbling but also should see some damage/melting of the foam cells. Could also run another using a heat tape in that area to check surface temperature. 3. If bubbling is all the way through the laminate layer, try cutting back the laminate layer to look at the ABS substrate. If there is a starburst or pitting pattern to it beneath or any voids in the ABS substrate, you could have moisture in ABS layer. Check to ensure sheet is dry if it has been left open. Could be from extrusion process if not environmental.

Bumps or indents	 	1. Contamination in ABS substrate 2. Moisture in ABS substrate or laminate layer 3. Air pockets in ABS sheet 4. Air entrapment between sheet and mold 5. Bumps or debris on mold surface 6. Debris in between sheets	1. Look on back of sheet. If some defect also on ABS side, could have a contaminant. Cut open and look with microscope. SIMONA PMC can identify using FTIR if samples returned. 2. Moisture in ABS layer often causes pitting on backside. If severe pitting on back of sheet, could be from extrusion. If back of sheet is ok but severe ABS pitting post-forming, could be getting moisture from storage conditions. 3. Cut open sheet, if smooth air pocket without contaminants in ABS layer could be air entrapment during extrusion. 4. If B side of ABS shows an indentation as well but cutting open doesn't show a void in cross-section, ensure vacuuming properly and not entrapping air during forming. 5. Ensure mold surface is clean and there is not router debris, dirt, wood etc. that can imprint into the A or B sides of the sheet. 6. Check between sheets for debris such as core hairs, router debris, dust, dirt, etc. This can permanently indent the laminate surface and make the indent larger post-forming.

“Cottage cheese” or mottling look	 	1. Thin spot in ABS substrate 2. Too much heat in that particular area on ABS side 3. Draft in that area of the form	1. If same spot every time, flip sheet around 180 degrees. If defect is now opposite side, sheet issue. If still the same spot consider heating issue in forming. Gauge sheet using as little pressure as possible (laminate layer depresses under pressure) to see if there is a thin spot across width of sheet. 2. Use heat tapes to determine temperature in that area compared to others. Screen the hot spot or turn down temperature if you have zone control. Likely defect seen on ABS side as well as A surface, play with B side temperatures to fix. 3. Watch sag coming out of the oven. It the sag looks good watch to see if there is a draft in the mottled area while the sheet is still sagged. Blowing of the hot plastic could cause a wave/mottled effect.
Delamination of vinyl from ABS Substrate	 	1. Contamination of the ABS substrate 2. Severe moisture in ABS substrate 3. Missing adhesive on laminate 4. Forming temperature too cold on the laminate	1. The laminate will not stick well to non-ABS substrates. Contamination with an olefin will cause delam. Send samples to SIMONA PMC for FTIR analysis. Delamination from contamination will cause perfect separation of laminate from ABS surface, no tearing of the foam layer. 2. Check for severe pitting or bubbling in the ABS substrate. If seen in parts but not sheet, could be from environmental/storage conditions. Ensure sheet is kept dry, dry if needed. 3. Typically, vinyl laminate temperatures under 290°F will cause tearing rather than delamination but could cause improper full cure of adhesive layer. Use heat tape or IR gun to ensure laminate temperatures are getting over 290°F.

Denting on laminate side		1. Debris between sheets or parts 2. Stacking of parts 3. Tools or other objects being set on the sheet or parts	1. Check to see if any debris is between sheets prior to forming. Check if debris is getting onto part surfaces, particularly while hot. 2. Avoid stacking parts, denting likely on corners from this. Use cooling racks. 3. Don't allow tools or other objects, particularly anything with some weight to it, to sit on either the flat sheets or the parts. Top sheet of OneStep™ comes flipped over to avoid denting it with packaging.
Dirt on vinyl surface		1. Sheet or formed part encountered dirt, grease, etc.	1. OneStep™'s vinyl surface is relatively easy to clean. See Appendix A for cleaning instructions. Keep in mind anything impressed into the surface can leave a permanent dent but dirt, grease etc. on surfaces is likely cleanable.
Line across sheet width		1. Color streak in vinyl laminate 2. Sticking too middle extrusion roll 3. Roll bounce from extrusion	1. Feel line with fingertips on both A and B sides of sheet/part. If you cannot feel a gauge variation, it may be a color streak in the laminate layer. SIMONA PMC can help confirm with microscopy. 2. If you can feel some bump or gauge variation in the area of the line, this could be an extrusion issue. One root cause would be the sheet sticking and releasing from the middle roll causing a variation. 3. Other option is if the roll was opened and closed by the operator and that sheet was not scrapped as it should have been. In this case only 1 sheet should be affected.

Line in machine direction, along length	 	1. Worm track from extrusion 2. Thick or thin spot in ABS substrate	1. Worm tracks will leave a line on the ABS substrate backside as well. This is an air bubble caught in the bead during extrusion which forms a line on the B side of the sheet. 2. Forms can thin out and cause a line if there is a thin gauge spot. Measure gauge every 6 inches across the width and see if a thin spot lines up with where you're seeing the line.
Scratches on laminate side	 	1. From sliding sheets during packaging 2. Sliding or flipping sheets during forming	1. Laminate scratches easily, lift sheet from skid without scraping against sheet below. If scratches still present may be from handling at extrusion facility. 2. Watch your team handle the raw sheets, sliding or flipping sheets against the one below can easily scratch the vinyl surface.

Tearing of the vinyl	  	1. Excess stretch in extrusion 2. Forming temperature too cold for vinyl 3. Too much sag on part 4. Uneven clamping of vinyl laminate layer 5. Radius or corner too sharp/severe 6. Depth of draw not appropriate for thickness of sheet	1. The laminate has 190% maximum stretch. If tension is too high during lamination the laminate could tear when formed. Should look like a tear all the way through the vinyl layers. 2. Use heat tapes to determine temperature in the area. If under 290°F, it is too cold and vinyl may "tent" or tear some. 3. Too much sag can result in tearing as the laminate is stretched too much. More likely on deeper draw parts. 4. Due to laminate width limitations, the vinyl may not go all the way to the edges of the sheet. However, if one side has the laminate and sheet clamped and the other side just the ABS sheet portion, the weight of the laminate may cause the sag to slide nearer the side with the vinyl clamped, and the vinyl or ABS may tear near the opposite clamp. Ensure either both sides of vinyl are clamped at least some or both not clamped at all (ABS only). 5. Laminate may tear if corners are too sharp. Rounded corners of ½ inch minimum, up to 1 inch to be safe. 6. Similar to too much sag a draw that is too deep or just too severe (not enough draft) could cause tearing of the laminate due to localized over-stretching.
Trimming excess chaff		1. Improper router bit design 2. Routing too quickly	1. Use an up flute router. 2. Slow down router speed to see if that helps.

Warp		1. Excess sheet stress/orientation from extrusion 2. Uneven cooling of the part	1. Excess orientation during extrusion can cause warp in raw sheet. 2. Ensure even cooling, use fans as needed.
Webbing or chill marks		1. Sheet too hot/too much sag 2. Uneven temperatures in former 3. Vacuum rate too fast or uneven 4. Mold temperature too cold 5. Radius too tight or not enough draft	1. Lower heats or cycle time and see if that eliminates webbing. 2. Use heat tapes in area where you are getting webbing to determine if too hot in that spot. 3. Watch form to see if plastic is touching one area of the mold before others causing issue. 4. Ensure mold is not too cold from drafts, etc. to cause chill marks. 5. Radius at least ½ inch, up to 1 inch on larger parts. Severe corners or turns could cause webbing issues.
Wrinkles in corner or radii		1. Radius or corner design is too severe/sharp	1. Recommend ½ in. radii minimum may have to go up to 1 in. on larger parts.

Appendix: Vinyl Laminate Cleaning Instructions

OneStep™'s vinyl laminate surface is easy to clean. For surface dirt or light staining a mixture of soap and water with a damp cloth or soft sponge should be sufficient. Be sure to wipe away soapy water post-cleaning in case the soap would leave any residues on the surface. For more stubborn stains a 1:10 bleach water solution can be used. Just be sure to thoroughly wash the solution away after cleaning with clean water and try on a small spot first prior to large scale cleaning. Keep in mind that the vinyl laminate is more chemical resistant than the ABS substrate. The ABS can be degraded by these cleaning methods so take care not to get any chemicals on the ABS substrate and wash away immediately if exposure does occur. ABS should be cleaned with water only as necessary.

CUSTOM EXTRUSION SOLUTIONS

TPO | ABS | Acrylic | ASA | PC/ABS | Soft-touch

SIMONA PMC | +1 877 289 7626 | info@simona-pmc.com | www.simona-pmc.com